

REMARKS/ARGUMENTS

Favorable reconsideration of this application, as presently amended and in light of the following discussion, is respectfully requested.

Claims 15, 18, and 28-29 are currently pending and Claim 29 has been added for consideration. The changes and additions to the claims do not add new matter and are supported by the originally filed specification, for example, on page 28, lines 14-23.

In the outstanding Office Action, Claims 15, 18-19, and 25-27 were rejected under 35 U.S.C. §103(a) as unpatentable over Sugo et al. (U.S. Patent No. 5,308,467, hereinafter “Sugo”) in view of Liang et al. (U.S. Patent No. 6,649,037, hereinafter “Liang”).

The Advisory Action, indicates that Claims 15, 18, and 28 are rejected but does not appear to provide any explanation on the grounds for rejecting Claim 28.

With respect to the rejection of Claim 15 under 35 U.S.C. §103(a), Applicants respectfully traverse this ground of rejection. Claim 15 recites, *inter alia*,

deionization compartments, concentration compartments and electrode compartments partitioned from one another by a plurality of anion- and cation- exchange membranes between a cathode and an anode,

wherein, in a deionization compartment, one or more sheets of anion exchange fibrous materials and one or more sheets of cation exchange fibrous materials are alternately laminated on one another in a direction intersecting a water-passing direction from a water inlet to a treated water outlet of the deionization compartments such that opposite ends of each of the sheets of the anion exchange fibrous material and the sheets of the cation exchange fibrous material come into contact with both of an anion exchange membrane and a cation exchange membrane forming the deionization compartment, and

at least one of the sheets of anion exchange fibrous material and the sheets of cation exchange fibrous material is a material obtained by introducing ion exchange groups onto a substrate using radiation-induced graft polymerization.

In a non-limiting example of the invention defined by Claim 15, the specification describes that the claimed invention utilizes water dissociation at a contact point of an anion exchange group and a cation exchange group to produce  $H^+$  and  $OH^-$  to regenerate ion exchange groups. (See specification, page 7 line 11 to page 8, line 24, page 23, line 15 to page 24, line 9). In the non-limiting example, a sheet of anion exchange fibrous material and a sheet of cation exchange fibrous material are laminated to form a water dissociation field therebetween since a large number of contact points of anion exchange groups and cation exchange groups are formed. As a result, using the sheets of anion/cation exchange fibrous materials provides an advantage of increasing the adsorbing rate of ions on the sheets to increase the number of contact points, namely contact surface area, and thus to increase an occasion of water dissociation. (See specification, page 19, line 14 to 21, line 22). Thus, according to the non-limiting example of the invention defined by Claim 15, production of  $H^+$  and  $OH^-$  between the sheet of anion exchange fibrous material and the sheet of cation exchange fibrous material and thus regeneration of anion exchange groups on the sheet of anion exchange fibrous material and cation exchange groups on the sheet of cation exchange fibrous material can be achieved along with water dissociation occurring between the sheets.

In addition, in the non-limiting example, there are a large number of anion exchange groups lined up on the sheet of anion exchange fibrous material capable of transporting ions from one anion exchange group to the next anion exchange group toward a concentration compartment and there are a large number of cation exchange groups lined up on the sheet of cation exchange fibrous material capable of transporting ions from one cation exchange group to the next cation exchange group toward a concentration compartment.

Applicants submit that Sugo and Liang fail to disclose or suggest all the features of Claim 15.

Sugo describes an electrically regenerable demineralizing apparatus which uses ion exchangers that are produced by radiation-initiated graft polymerization and that are packed in the demineralizing compartment of an electrodialyzer. (See Sugo Abstract). The electrically regenerable demineralizing apparatus of Sugo may use a mosaic ion exchanger that consists of alternately arranged cation- and anion-exchange groups. (See Sugo Abstract).

The Office Action of August 24, 2009 acknowledges that Sugo does not disclose or suggest “in a deionization compartment, one or more sheets of anion exchange fibrous materials and one or more sheets of cation exchange fibrous materials are alternately laminated on one another,” as recited in previously presented Claim 15.

The Office Action relies on Liang to remedy the deficiencies of Sugo with regard to previously presented Claim 15.

Liang describes an electrodeionization apparatus and method for purifying a fluid. (See Liang, Abstract). The electrodeionization apparatus of Liang includes at least one ion-depletion compartment, a first layer of a first ion exchange material positioned in the at least one ion-depletion compartment, a second layer of a second ion exchange material positioned adjacent and downstream of the first layer, and a third layer comprising anion and cation exchange material positioned adjacent to and downstream of the second layer. (See Liang, column 2, lines 38-47).

The Office Action appears to assert that an anion layer 61, a cation layer 63, and a mixed ion exchange material 67 of Liang corresponds to “in a deionization compartment, one or more sheets of anion exchange fibrous materials and one or more sheets of cation exchange fibrous materials are alternately laminated on one another,” as recited in previously presented Claim 15. (See August 24, 2009 Office Action, page 2). Liang states that

Once ionized, cationic species can be transported, under the influence of an electric field, through a layer of cation

exchange resin or mixed ion exchange resin. . . . This same lack of charge may also contribute to factors that make it difficult to transport these species under the influence of an electric field, such as in an electrodeionization device. To facilitate the transfer of weakly ionizable species, the pH of the water may be adjusted, for example, by the addition of an acid or base. However, the introduction of an acid or base into a purified fluid may not be preferred, as these compounds may provide a possible source of contamination, may contribute to the conductivity of the water, and may also result in fluctuation in pH because of the absence, or near absence, of buffering capacity.<sup>1</sup>

By splitting water and disproportionally transferring either hydrogen ions or hydroxide ions out of the depletion compartment, pH may be affected. In response to this variation in pH, some molecules of the weakly ionizable species may become ionized and therefore can be influenced by an electric field. A portion of these molecules may be transferred out of the water sample, resulting in a fluid that contains a lower concentration of the particular species.<sup>2</sup>

Most preferred are ion exchange resins such as, for example, anion exchange resins, cation exchange resins, and mixtures thereof. These include Type I and type II anion exchange resins, strong or weak acid cation exchange resin, strong or weak base anion exchange resins and mixtures thereof. . . . Most preferably, if the layer is a layer of cation exchange resin, the layer also include a dopant.<sup>3</sup>

At the junction of cation and anion exchange material, and with adequate electric potential, water splitting may occur in an electrodeionization apparatus. The resulting concentrations of hydrogen (hydronium) and hydroxide ions may be retained in the ion-depletion compartment or may partially, or totally, be transported out of the ion-depletion compartment. For example, hydrogen ions may pass through a cation permeable membrane in response to, for example, an electric potential and/or a concentration gradient. If an unequal number of hydrogen and hydroxide ions are transported out of the ion-depletion compartment, the pH of the fluid will be adjusted either up or down, depending on the transport differential between the hydroxide and hydrogen ions. . . . Because pH adjustment by this method may be a result of water splitting and the unequal transport of hydrogen and hydroxide

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<sup>1</sup> See Liang, column 5, lines 27-55.

<sup>2</sup> See Liang, column 6, lines 9-16.

<sup>3</sup> See Liang, column 6, lines 52-63.

ions from the water, rather than due to the addition of a basic or acidic substance, the pH of the water may be adjusted while maintain or even decreasing, the conductivity of the water. Thus, a water sample may be adjusted to a pH that promotes the ionization of a weakly ionizable species without the introduction of additional compounds that may hinder water quality and cause fluctuations in pH.<sup>4</sup>

Preferably, the mixed ion exchange material is in an electrodeionization device and most preferably, the water is passed through the electrodeionization device after it passes through a series of homogeneous or doped anion/cation or cation/anion exchange layers.<sup>5</sup>

Improved results may be achieved by using alternating layers of anion, cation and mixed ion exchange material, and the volumetric and surface area ratios of each layer in relation to another may be varied. . . . to remove weakly ionizable anionic species from a water, . . . most preferred is a volume of anion exchange material that is equal to or greater than three times the volume of the cation exchange material. The inverse may be preferred for the removal of weakly ionizable cationic species.<sup>6</sup>

Several layer patterns of ion exchange material that may be useful . . . the configurations may be . . . separated by inert or electroactive screens or by other inert or electroactive materials such as glass, carbon or polymeric materials.<sup>7</sup>

Liang, in Figs. 4A-4F, shows a mixed bed of a first layer of an anion exchange resin material 128 with a dopant material 138, and a second layer of a cation exchange resin material 130. Liang, in Fig. 5, shows that feed water is passed through a first cell including cation exchange material 51 and anion exchange material 53 and then passed through a second cell including mixed ion exchange material 55. Liang, in Fig. 6, shows that feed water is passed through a first module including an anion layer 61 and cation layer 63 and then passed through mixed ion exchange material 67. Liang, in Fig. 7, shows that feed water

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<sup>4</sup> See Liang, column 6, line 64 to column 7, line 44.

<sup>5</sup> See Liang, column 9, lines 6-10.

<sup>6</sup> See Liang, column 10, lines 9-24.

<sup>7</sup> See Liang, column 10, lines 47-62.

is passed through a first cell of anion exchange material 71, a second cell of cation exchange material 73 and then a third cell of a mixed ion exchange material 75.

Liang, in Fig. 8, shows that feed water is passed through cation exchange layer 81, anion exchange layer 83 and then mixed ion exchange layer 85. Liang, in Fig. 9, shows that feed water is passed through a cell 71 of cation exchange material, and then feed water is split to three cells 92, 93, 94 of anion exchange material and then passed through three cells 95, 96, 97 of mixed ion exchange material.

That is, Liang describes in all embodiments that feed water is passed through the first anion exchange resin or the cation exchange resin, the second cation exchange resin or the anion exchange resin, and finally the mixed ion exchange resin bed. The mixed ion exchange resin bed of Liang is thus necessary to remove ionized ions to produce pure water having high purity.

Liang describes that the ion exchange resin is most preferred since the mixing ratio of the anion exchange resin and the cation exchange resin can be easily varied. Liang also describes that the volume ratio of anion exchange resin to cation exchange resin is most preferably 3:1 to remove weakly ionizable anionic species from water and the inverse is preferred for removal of weakly ionizable cationic species. (See Liang, column 15, line 19 to column 16, line 55). Thus, Liang requires the mixed ion exchange resin bed to remove ions from water.

Furthermore, Liang discloses that water splitting is used to adjust pH of ion-exchange layers to promote the ionization of a weakly ionizable species. Liang describes that a dopant is added to cause water splitting. (See Liang, column 14, lines 22-48). To make effective an addition of dopant, an ion exchange resin is preferred and 1 cm or more of height of the resin layer is necessary. The addition of dopant prevents transport of ions. For example, anion

species cannot move toward a cathode in an anion exchange resin layer with cation exchange resins as the dopant since movement of anion species is prevented by cation exchange resins.

Liang also describes that layers of ion exchange resin may be separated by inert materials such as glass, carbon or polymeric materials. (See Liang, column 10, lines 57-65). As a result, the number of contact points of cation exchange groups and anion exchange groups is reduced.

Thus, Liang uses water splitting to adjust pH to promote the ionization of the weakly ionizable species but not to produce  $H^+$  and  $OH^-$  to regenerate ion exchange groups. In contrast, as described above in the non-limiting example of the invention defined by Claim 15, production of  $H^+$  and  $OH^-$  between the sheet of anion exchange fibrous material and the sheet of cation exchange fibrous material and thus regeneration of anion exchange groups on the sheet of anion exchange fibrous material and cation exchange groups on the sheet of cation exchange fibrous material can be achieved in addition to water dissociation occurring between the sheets.

Furthermore, Liang does not teach utilization of water dissociation to produce  $H^+$  and  $OH^-$  to regenerate ion exchange groups between the sheet of anion exchange fibrous material and the sheet of cation exchange fibrous material intersecting a water-passing direction in which a plurality of such sheets set are disposed in the deionization compartment in the present invention.

Therefore, Liang does not explicitly disclose or suggest the one or more sheets of anion and cation exchange fibrous materials of Claim 15.

Accordingly, Applicants respectfully submit that Claim 15 patentably distinguishes over Sugo and Liang, either alone or in proper combination.

With respect to the rejection of Claim 18 under 35 U.S.C. §103(a), Applicants respectfully traverse this ground of rejection. Claim 18 recites, *inter alia*,

deionization compartments, concentration compartments and electrode compartments partitioned from one another by a plurality of anion- and cation- exchange membranes between a cathode and an anode,

wherein, in a deionization compartment, one or more sheets of anion exchange fibrous materials and one or more sheets of cation exchange fibrous materials are alternately laminated on one another in a direction intersecting a water-passing direction from a water inlet to a treated water outlet of the deionization compartment such that opposite ends of each of the sheets of the anion exchange fibrous materials and the sheets of the cation exchange fibrous material come into contact with both of a sheet of anion exchange fibrous material and a sheet of cation exchange fibrous material which are respectively disposed in parallel with the surface of the anion exchange membrane and the surface of the cation exchange membrane forming the deionization compartment.

Applicants submit that Sugo and Liang fail to disclose or suggest all these features of Claim 18.

Sugo describes a mosaic ion-exchanger that is disposed parallel to water to be treated in a demineralizing compartment. In Sugo's apparatus, there are spaces between the mosaic ion-exchanger and a frame of the demineralizing compartment since they are in parallel. Thus, a part of the water bypasses the mosaic ion-exchanger without contacting the mosaic ion exchanger.

The Advisory Action of February 24, 2010 appears to assert that with regard to Sugo that Claim 18 “would likewise allow the water bypasses, since they too are in parallel.” (See February 24, 2010 Advisory Action, page 3). In addition, the Advisory Action of February 24, 2010 appears to assert that “[w]ith respect to the water flow through the spaces between the ion-exchange resin that is supposed to be different from the claimed apparatus, it is unclear and applicants have no cogently explained how the water would pass through the cell,



if no through spaces between ion exchange material.” (See February 24, 2010 Advisory Action, page 3).

Claim 18 specifically recites “one or more sheets of anion exchange fibrous materials and one or more sheets of cation exchange fibrous materials are alternatively laminated on one another in a direction intersecting a water-passing direction from a water inlet to a treated water outlet” and “**opposite ends of each of the sheets of the anion exchange fibrous materials and the sheets of the cation exchange fibrous material come into contact with both of a sheet of anion exchange fibrous material and a sheet of cation exchange fibrous material** which are respectively disposed in parallel with the surface of the anion exchange membrane and the surface of the cation exchange membrane.”

In a non-limiting example of the invention defined by Claim 18, the specification shows in Figure 3, a large portion of feed water passes through the laminated layers of the sheets of the anion exchange fibrous material and the cation exchange fibrous material and is contacted to the anion exchange groups on the sheet of anion exchange fibrous material and the cation exchange groups on the sheet of cation exchange fibrous material, alternatively. (See specification, Fig. 3). The non-limiting example also describes that the sheets are arranged so as to pass a very small portion of feed water through between the laminated sheets of anion exchange fibrous material and cation exchange fibrous material and the sheet of anion exchange fibrous material adjacent to anion exchange membrane, and between the laminated sheets of anion exchange fibrous material and cation exchange fibrous material and the sheet of cation exchange fibrous material adjacent to cation exchange membrane, respectively. (See specification, page 24, line 10 to page 33, line 1, Fig 3).

Additionally, in the non-limiting example, at the contact area between the anion exchange membrane and the anion exchange fibrous material, water dissociation occurs and

the same type of ion exchange groups are lined up in series on the ion exchange fibrous material. An anion adsorbed to one anion exchange group on the anion exchange fibrous material is replaced with  $\text{OH}^-$  generated by water dissociation and desorbed from the anion exchange fibrous material. Then, the desorbed anion is adsorbed to the next anion exchange group on the anion exchange fibrous material. Thus, adsorbed anions are transferred from one ion exchange group to next ion exchange group toward a concentration compartment. On the other hand, at the contact area between the anion exchange membrane and the cation exchange fibrous material, water dissociation occurs.

A cation adsorbed to one cation exchange group on the cation exchange fibrous material is replaced with  $\text{H}^+$  generated by water dissociation and desorbed from the cation exchange fibrous material. Then, the desorbed cation is adsorbed to the next cation exchange group on the cation exchange fibrous material. Thus, cations are transferred from one cation exchange group to next cation exchange group on the cation exchange fibrous material toward a concentration compartment.

In addition, the contact area between cation exchange fibrous material and anion exchange membrane provides superior water dissociation since potential gradient at the contact area between vertically placed anion exchange membrane and horizontally placed cation exchange fibrous material is larger than one between horizontally placed anion exchange fibrous material and horizontally placed cation exchange fibrous material. Thus, ions can be transferred through the same type of ion exchange group toward electrodes.

Accordingly, Applicants respectfully submit that it is clear how the water would pass through the compartments.

Therefore, Sugo does not explicitly disclose or suggest the one or more sheets of anion and cation exchange fibrous materials of Claim 18.

Liang has been considered but fails to remedy the deficiencies of Sugo with regard to previously presented Claim 18. Therefore, Applicants submit that previously presented Claim 18 (and all associated dependent claims) patentably distinguishes over Sugo and Liang, either alone or in proper combination.

The Office Action also appears to assert that it would be obvious to modify the mosaic ion-exchanger of Sugo with the anion layer and the cation layer of Liang. (See August 24, 2009 Office Action, page 2). However, the mosaic ion exchanger of Sugo is not an anion exchanger or cation exchanger but rather a mixed ion exchanger. Accordingly, if Liang was modified with the mosaic ion exchanger of Sugo, the deionization compartment would be filled with a plurality of the mixed ion exchangers.

Thus, Applicants submit that it would not be obvious to a person of ordinary skill in the art would not modify the ion exchange resin of Liang based on the description of a mosaic ion exchanger in Sugo to achieve the advantages described above.

Accordingly, Applicants respectfully submit that amended Claim 18 (and all associated dependent claims) patentably distinguishes over Sugo and Liang, either alone or in proper combination.

Consequently, in light of the above discussion and in view of the present amendment, the outstanding grounds for rejection are believed to have been overcome. The present application is believed to be in condition for formal allowance. An early and favorable action to that effect is respectfully requested.

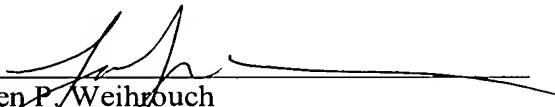
Respectfully submitted,

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